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THE NEED FOR BASIC SKY STUDIES

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Project No. 378
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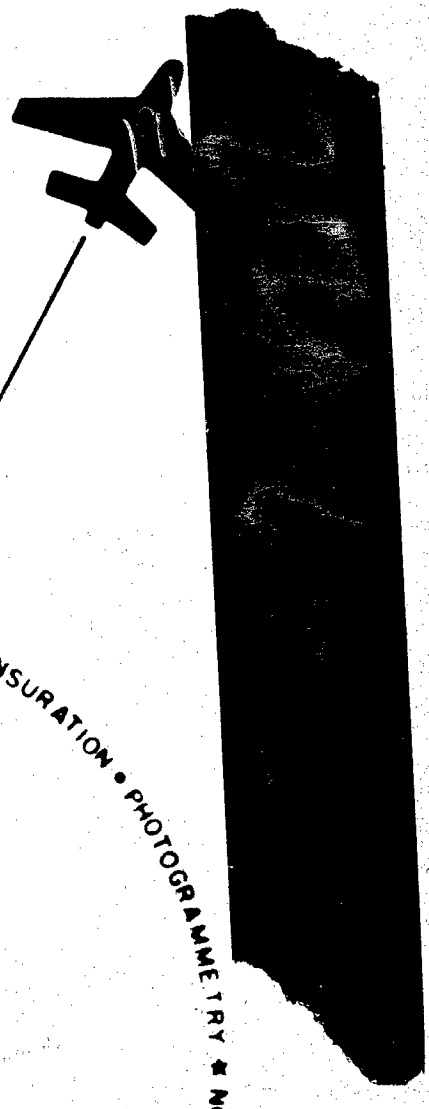
E. O. 683-44

G. H. Harding, Laboratory Director

12 June 1951



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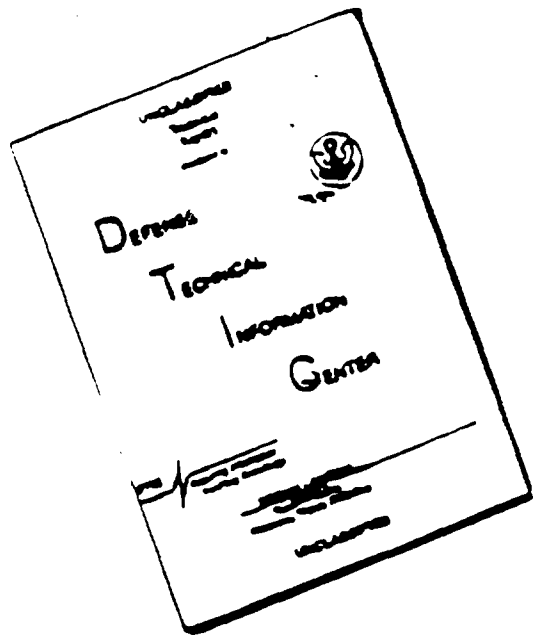

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MAPPING AND CHARTING RESEARCH LABORATORY

Technical Paper No. 143

THE NEED FOR BASIC SKY STUDIES

Prepared by
Dr. J. Allen Hynek
Consultant, Mapping and Charting Research Laboratory
Assistant Dean, Graduate School, Ohio State University
Director, McMillin Observatory

The Ohio State University Research Foundation
Project 378

for the
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Contract No. AF33(038)-3729
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Columbus, Ohio
12 June 1951

FOREWORD

This report was prepared by the Mapping and Charting Research Laboratory of the Ohio State University Research Foundation, under USAF Contract No. AF33(038)-3729. The contract was administered under the direction of the Mapping and Charting Branch, Photographic Laboratory, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, with Mr. James J. Deeg, Chief of the Mapping and Charting Branch, as Project Officer.

ABSTRACT

This paper, one of thirteen papers concerning various aspects of mapping and charting, was presented by the author at the Eighth Meeting of the Panel on Cartography and Geodesy, Committee on Geophysics and Geography, National Research and Development Board, held November 3, 1950, at the Mapping and Charting Research Laboratory, Ohio State University Research Foundation, Columbus, Ohio.

Attention is called to atmospheric phenomena long familiar to the astronomer but which he has regarded almost entirely in a negative sense. It appears possible today with advanced techniques of photo-electric photometry to turn these phenomena of "seeing" and "twinkling" to good use in the study of the physical conditions of the upper atmosphere. Several approaches to the study of these phenomena in a positive way are suggested. In military terms these have been termed for quick reference "Operation Twinkle" and "Operation Sky Star" and refer to the problems of astronomical seeing and of sky noise respectively.

THE NEED FOR BASIC SKY STUDIES

I speak not as one who presumes to be conversant with your highly specialized field, but as an astronomer who merely wishes to call your attention to certain phenomena long familiar to astronomers. These phenomena, because of the availability today of infinitely more precise means of measurement than when these matters first were pointed out, may now be utilized to give us basic information about the structure of the atmosphere.

Recent advances in photoelectric techniques, notably the photomultiplier cell which raises sensitivity levels essentially to the theoretical limit, the lead sulfide and lead telluride photoconductive cells, which allow photoelectric investigation to be carried into the infrared, and the development to new levels of precision of both DC and AC amplifiers, as well as the introduction of pulse counting techniques in photoelectric work, which allow a higher order of discrimination of the received signals-- all these offer opportunity for quantitative measures of these phenomena long familiar to the astronomer as a by-product of his work, but which now are assuming an importance all their own.

Their importance has two aspects: that relating to basic studies of the earth's atmosphere, and that relating to military purposes involving mapping and charting, navigation, signaling, and very possibly meteorology. Because of the military aspects of the importance of these new proposed studies, I am not aware, as a civilian astronomer, how much classified work may be in progress in these areas. None the less it may be well to call attention to several avenues of investigation which

might be undertaken with profit both from the standpoint of military applications and of advancing our knowledge of the earth's atmosphere.

The astronomer is beset by two great obstacles in his investigations of the universe: daytime, which is simply the result of the action of the earth's atmosphere on light coming from the sun, and "poor seeing," which is the result of the action of the earth's atmosphere on light coming from the stars at night (and, of course, in the daytime too). Both effects would not exist if the earth had no atmosphere; stars would shine in the "daytime" and at night, which would differ from day only in that an especially bright star among the thousands, the sun, would be absent.

The new photoelectric advances offer an opportunity for analyzing these two phenomena - daytime, that is, the daylight sky, and "poor seeing" - with the definite promise that such studies will advance our basic knowledge of the atmosphere.

Let us consider "poor seeing" first. I should like to outline a series of experiments and measures, and because of the manifest military aspects of such information, we might suitably term, "operation twinkle."

The twinkling of the stars arises from thermal disturbances in the atmosphere - inversion layers and general turbulence - anywhere from a few feet in front of the telescope out to the upper reaches of the atmosphere. Twinkling is synonymous with "bad seeing", for when the atmosphere is unsteady, astronomical images are likewise unsteady and "dance" about, making certain kinds of astronomical work difficult if not impossible.

The "dance" of the image is not always the same. The most frequent is a rapid change in form of the image. Without an atmosphere, a star image would approximate a point. To be exact, every star image would be the familiar diffraction pattern of a point source. The earth's atmosphere rarely allows a true diffraction pattern to be seen. The image looks more like a highly agitated, luminous amoeba. The fluctuations in form of the image are rapid, and may range from one or two to several hundred fluctuations a second.

The atmosphere also causes the image as a whole to oscillate over several seconds of arc and in a period often of several seconds. This has been termed "dancing" by some observers and the terms "scintillation" and "pulsation" have been applied to the change of intensity and size, respectively. Regardless of terminology, a star image, because of the action of the atmosphere, does change in size, intensity, and position.

Until recently it has not been possible to make truly quantitative measures of these changes, changes which are indices of atmospheric conditions such as the existence of temperature inversion layers and their approximate height, and of layers of atmospheric turbulence. The frequency spectrum of "seeing" should be investigated in detail, and the relative strength of the low frequency changes (a few per second) and those of high frequency (more than one hundred cycles per second) correlated with meteorological conditions in the upper atmosphere.

Stars can be observed telescopically in the daytime. Generally, "seeing" is very much worse in the daytime. A quantitative intercomparison

of night and day seeing conditions is almost certain to be of value in the study of atmospheric conditions. Since so very little truly quantitative work has yet been done (to the best of my knowledge) little can be said of the ultimate value of these suggested investigations other than that they hold considerable promise. Little more can ever be said of basic research. If we know the answer before we start, it wouldn't be research.

There is another aspect to this problem which is related to the above and yet is basically different. This is the problem of "sky noise." In "seeing," a point source of light (starlight) passes through the atmosphere and one can study the distortions; the essentially flat wave-front suffers because of this passage. By focal adjustment of the telescope, even some isolation of the layers most effective in producing this distortion can be made.

If, however, we isolate a tiny portion of the daylight sky, no larger in size than the average apparent diameter of a star, how will its fluctuations in brightness compare with that of a star? Since the size is constant, "dancing" and pulsation will not enter. To what extent will our "sky-star" twinkle, or with what frequencies will it pulsate? How are the amplitudes at the various frequencies related? How do the above parameters vary with wavelength, i.e., with position in the spectrum, of the sky? How will the variations differ within a strong absorption band, say, of water? And finally, how are all these variables related to angular distance from the sun and from the zenith, and how do they vary seasonally and with altitude above sea level. Perhaps there may even be a variation with the solar cycle!

The purpose of this paper, let us repeat, in conclusion, is not to formulate a specific program but to call attention to the physical information that might become available for both basic and military needs if "operation twinkle" and "operation sky-star" are set up to build upon previous work done in these fields, but utilizing the recent, striking advances in photoelectric techniques.

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1 March 2001

88 CG/SCCM
Bldg 676 Area B
2435 5th Street
WPAFB OH 45433-7802

Defense Information Systems Agency
DTIC
Attn: Larry Downing
8725 John J Kingman Rd Ste 0944
Ft Belvoir VA 22060-6218

Dear Mr. Downing,

This is in response to your 29 Jan 01 letter concerning DTIC-RS FOIA 2001-45, Ralf Hartel request for AD B217522, *The Need for Basic Sky Studies*, dated June 1951.

The document was cleared for release by AFMC/PAX on 27 Feb 01 and is determined Distribution A, approved for public release.

Point of contact for this action is Jan Bright (937) 904-8187 or fax (937) 656-4295.

Sincerely

Janice R Bright

JANICE R. BRIGHT
FOIA Analyst

1 Atch
Your Ltr, 29 Jan 01

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